storage area, probably reduces the release of previously-trapped material, including sediments with oil adsorbed to the sediment surfaces.

One problem observed with this design is that much of the oil retained by gravitational separation is probably lost during higher flows. Loss during high flows is assumed because the "strings" of polypropylene were found "hanging" on the high-flow outlet when the units were removed from the field for bench testing. Stains on the outside of the sock also suggest that oil had been carried out through the overflow outlet during a storm. Stormwater services is changing the design to "contain" the polypropylene absorbent material in a net that prevents its release during high-flow storm events.

Conclusions Regarding the Removal of Hydrocarbons

- The Stormwater Service units gave acceptable performance throughout the test sequence. This appears to be attributable to the effectiveness of polypropylene strips and the improved flow path that helped the insert retain the capacity of its treatment area. The overall removal efficiency, however, may not be as high as found in the bench tests because it appears that oil, captured gravitationally during gentle storms, is subsequently washed out during a larger storm. Servicing after about 5 inches of rainfall is suggested by the tests.
- The Enviro-Drain unit provided a degree of oil and grease removal when in good condition but was unable to remove oil and grease concentration to below the 10 mg/L target. This insert will have to be serviced more frequently than the Stormwater Services unit (perhaps as often as after an inch or two of rain) to ensure the media surface and screens in the bottom the bottom the trays are not clogged. Some degree of maintenance will probably be needed after each inch of rainfall, but absorbant will probably not have to be replaced during each maintenance visit.
- Of the three Aqua-Net configurations tested, the unit used during the first sequence (AN-A) was most successful at reducing petroleum hydrocarbons. Removal rates for this unit were comparable to the performance of the Enviro-Drain.
- The less effective performance of the Enviro-Drain and one of the Aqua-Net units was likely due to the rapid decrease in hydraulic capacity of their respective treatment areas. Blinding of the filter surfaces resulted in overflow even at relatively low flow rates.

2.2C Metals

During the first test sequence, inflow and outflow sample analyses included total copper, lead and zinc, and dissolved copper and zinc. Sampling for dissolved copper and zinc was discontinued after the first (new-condition) test because inflow and outflow levels and/or the differences between inflow and outflow values were too close to the detection limits to allow meaningful analyses. Total copper and lead were sampled twice after field conditioning, and total zinc was sampled after three field-conditioning sessions.

Data from the analyses of total recoverable metals are presented in Figures 8 through 10. These data are presented in the same manner as were the TSS data above; bars indicate the mean inflow concentration of replicate samples collected for each bench test, diamonds indicate the mean change in concentration after the test water passed through the insert, and the whiskers indicate the 90 percent confidence interval about the mean change in concentration. As with the TSS values, the performance did not vary enough between inserts or between test sessions to warrant discussion of the differences between the performance of individual units, or of changes in performance over time. Figures 8 through 10 are provided only to illustrate that none of the units appeared to provide a discernible removal of dissolved metals or those associated with the very fine sediment in the test water. In some cases, metals appear to have been released along with sediment trapped during the field-conditioning sessions. Data from these latter sessions are not included in the graph but are presented in the complete data set in Appendix B.

Figure 8. Total Copper Results. Diamonds indicate the change in mean TP concentration, whiskers show 90% confidence interval about the change, and bars indicate mean inflow concentrations.

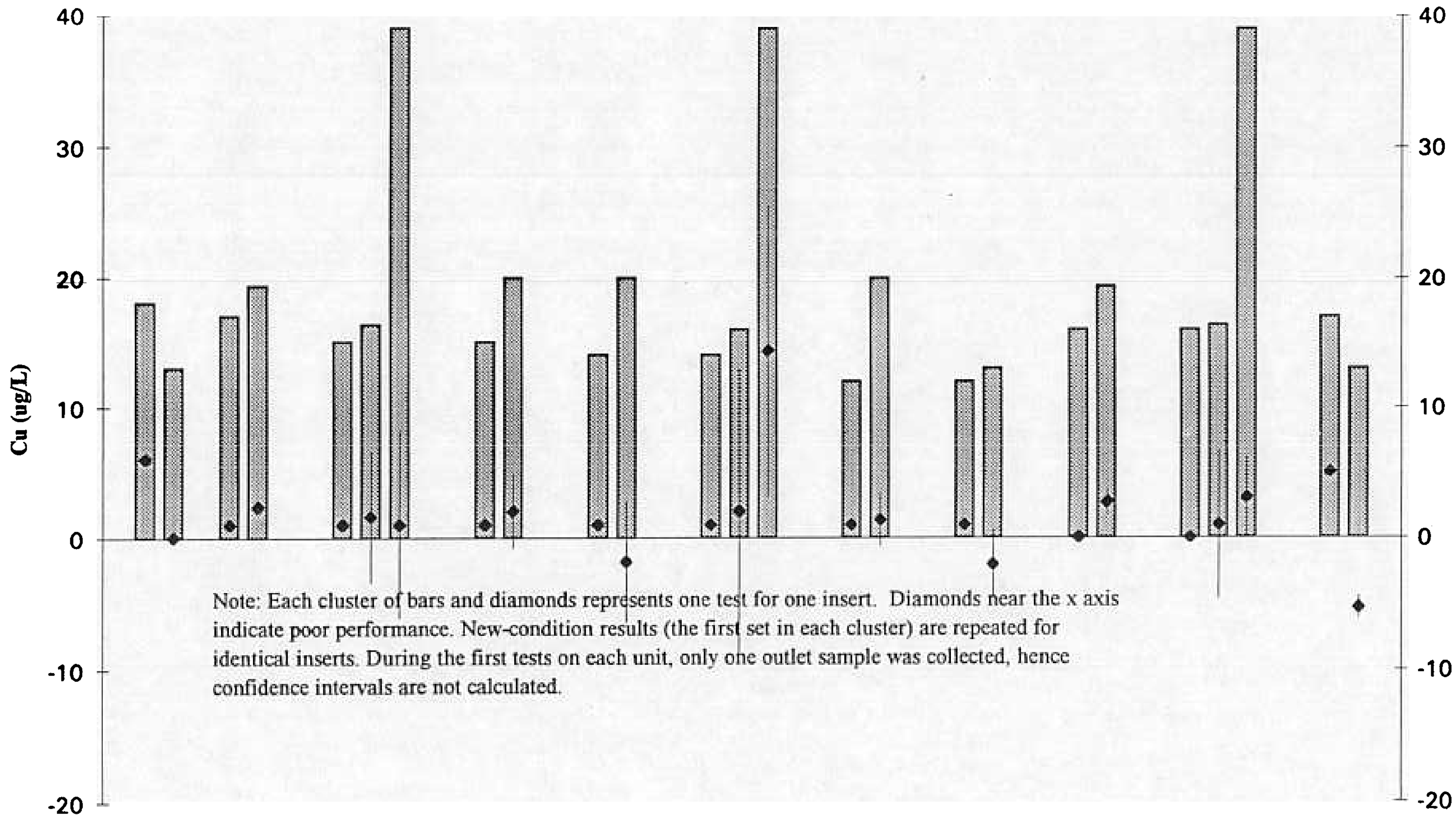


Figure 9. Total Lead Results. Diamonds indicate the change in mean lead concentration, whiskers show 90% confidence intervals about the change, and bars indicate mean inflow concentrations.

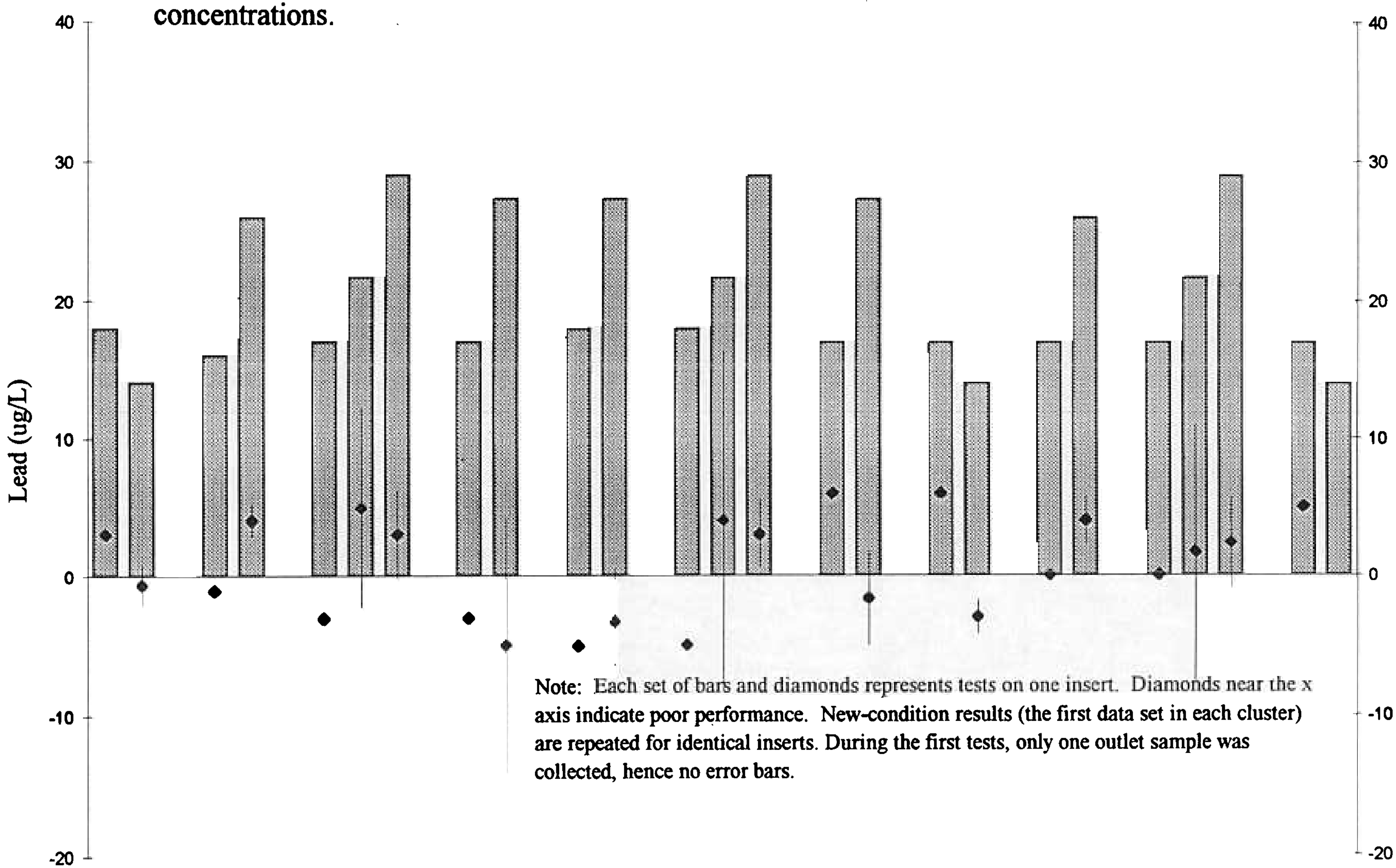
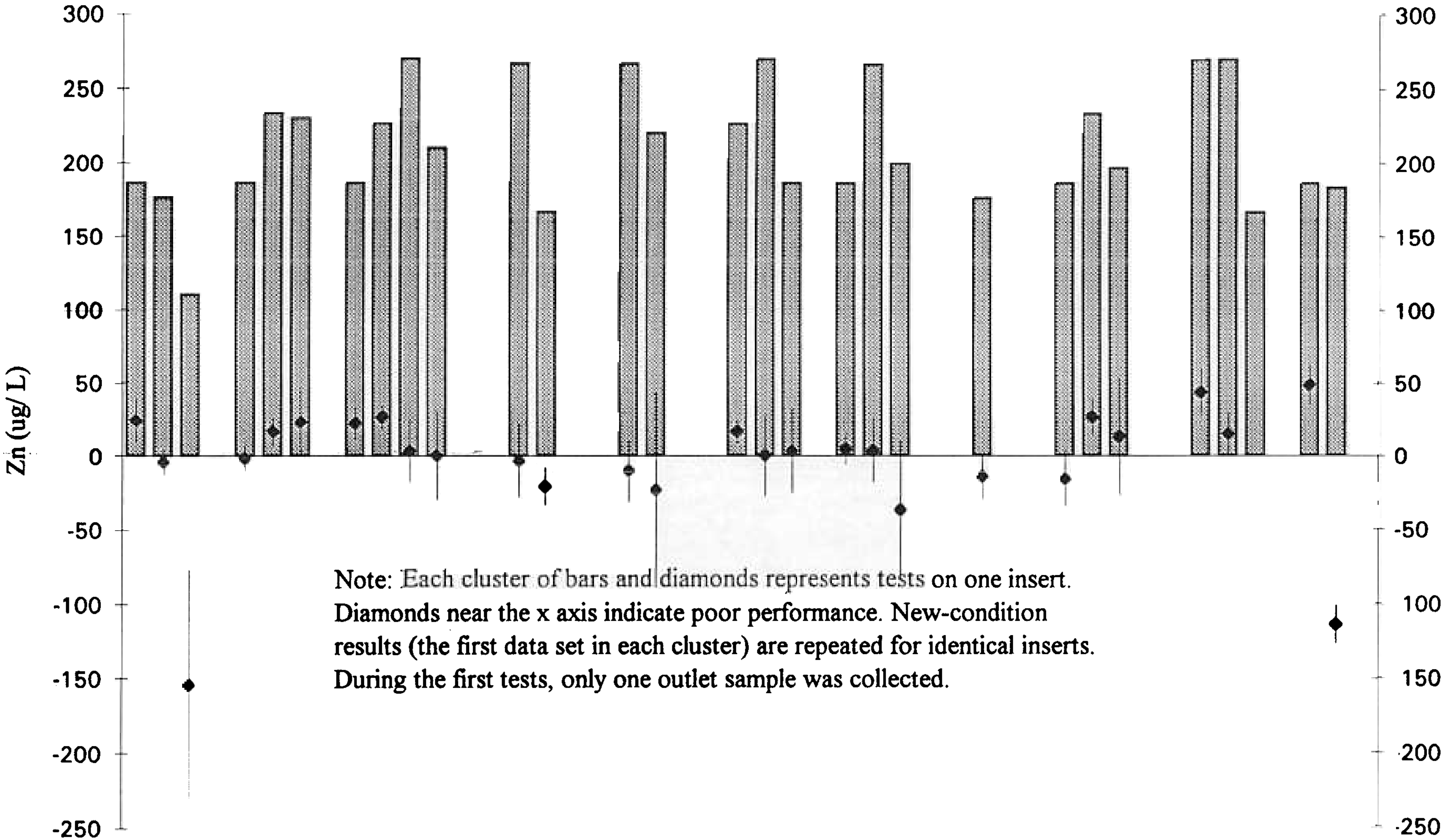


Figure 10. Total Zinc Results. Diamonds indicate the change in mean zinc concentrations, whiskers show the 90% confidence interval about the change, and bars indicate the mean inflow concentrations.

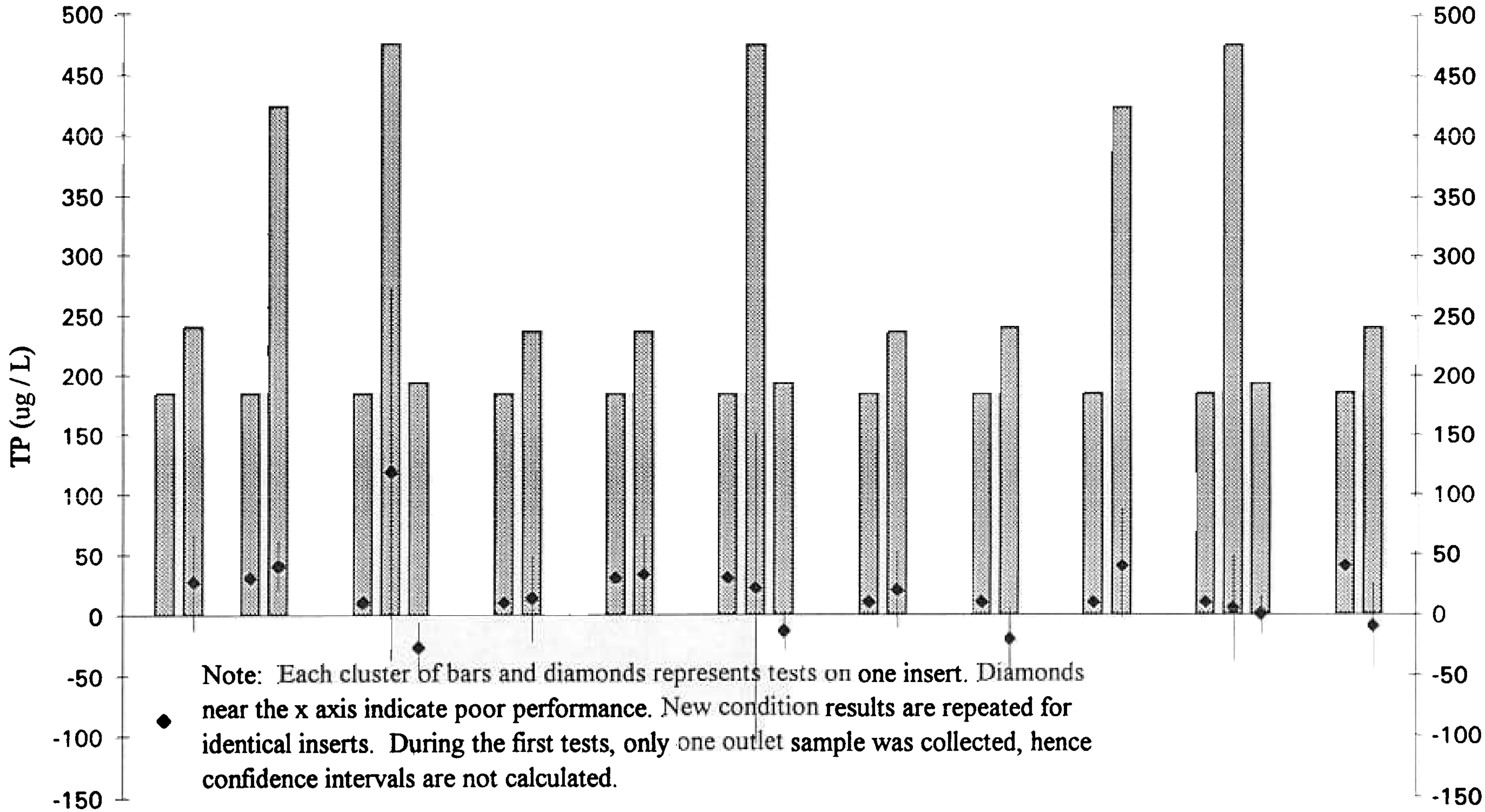


2.2D Nutrients

The only nutrient included in the study was total phosphorus. Total phosphorus was analyzed during the first two test sessions of the first test sequence. Inserts were tested for phosphorus removal when new, and again after 2 or 3 inches of rain (47 to 65 days in the field) depending on field location.

Total phosphorus data are presented in Figure 11 using the same conventions used in the above TSS and metals charts. As with the total metals results, the testing offered no indication that the inserts were effective at removing total phosphorus associated with the very fine sediment in the test water.

Figure 11. Total Phosphorus Results. Diamonds indicate the change in mean TP concentration, whiskers show 90% Confidence intervals about the change, and bars indicate mean inflow concentrations.



CHAPTER 3 - Hydraulic Characteristics

3.1 Methods

Understanding the hydraulic characteristics of the inserts is important both in terms of knowing the conditions under which they may be used, and in knowing how they will affect the conveyance capacity of the inlets in which they are installed. Methods used to evaluate these characteristics are described in the following sections.

<u>Treatment Capacity</u>
Ideally an insert will able to treat flows up to the peak of the 6-month event (the Washington State Department of Ecology stormwater treatment design storm (Ecology, 1992)), with no water exiting the insert via its overflow area. Use of this criteria allows the inserts to be compared to other treatment BMPs such as grass swales and wet ponds and wet vaults.

To evaluate treatment capacity, hydraulic tests were performed on eight insert configurations before they were installed in the field. Tests conducted on inserts in this "new" condition provide the maximum flow rate each insert can handle through its treatment area. Table 1 lists the configurations used in this test. Flow data were also obtained during the pollutant removal testing described above.

The units were tested in their "new" condition by placing each unit in a catch basin. Water from a fire hydrant was discharged through a 1-foot HS flume located 20 feet upstream of the catch basin. Flow from the fire hydrant was controlled with an in-line valve. The valve and flume combination allowed the flow rate to be adjusted from zero to 167 gpm. The target flow rate for this test was 60 gpm which is the peak of the 6-month, 24-hour event for a 0.25 acre drainage area. The treatment capacity was defined as the flow rate (in gpm) at which water began to exit the insert via the overflow area.

During the first sequence of pollutant-removal testing (April - August 1994), most of the units experienced flows through the overflow areas even at the modest test flow of 6 gpm after minimal field conditioning. Consequently, during the second sequence, the degradation of the treatment-area was measured. After the bench-test sampling was completed, the flow rate was gradually increased up to 24 gpm. This test was limited to 24 gpm by the test apparatus, but was considered appropriate since excessive flushing of the inserts between field-conditioning sessions would adversely impact the remaining pollutant-removal tests. This flow limit did, however, mean that the data from these tests could not be compared to the 60 gpm target when the treatment capacity of an insert exceeded 24 gpm.

<u>Hydraulic Capacity</u>
Since the insert must not compromise the primary function of a catch basin (which is to prevent flooding), the insert must have a capacity that equals or exceeds the capacity of the catch basin grate even if the treatment area is clogged. To evaluate the capacity of the overflow area of the inserts, the treatment area of each insert was covered, forcing all water to exit the insert via the

overflow. Covering was accomplished with plastic sheeting and duct tape, except on the Stormwater Services Type II. For this unit, the fabric "sock" was tied closed immediately below the overflow area.

The flow objective of the hydraulic capacity test was 167 gpm. This rate represents the capacity of an 18- by 24-inch catch basin grate without flooding. A complete discussion of the flow rates used in the study may be found in Appendix A.

Hydraulic capacity tests were conducted on five configurations. These configurations are described in Table 1. The procedure followed in this test sequence was essentially the same as used in the treatment-capacity tests; however, during the hydraulic capacity tests, the maximum overflow rate was defined as the point at which the water level in the insert reached the bottom of the catch basin grate, rather than the bottom of the overflow area on the insert..

3.2 Results and Discussion

3.2A Treatment Capacity

Units in New Condition

The results of the first treatment-capacity tests are presented in Table 4. Six of the seven configurations tested had a treatment area capacity that exceeds the 6-month event peak of 60 gpm. One Enviro-Drain unit failed the test. The capacity of this unit, which used a very fine (32-mesh screen) was quickly reduced by fine sediment which washed from the pavement during the test. In contrast, the other three Enviro-Drain units had a coarse 12-mesh screen and did not clog.

Table 4. Treatment Capacities of the Inserts When in New Condition.

VENDOR	CONFIGURATION	CODE	MAXIMUM FLOW FRESH UNITS
Aqua-Net	With Absorbent W	AN-A	exceeded 167 gpm[1]
Aqua-Net	Without Absorbent W	AN-S	exceeded 167 gpm
Enviro-Drain	Coarse screen, single shallow tray	ED-S	exceeded 167 gpm
Enviro-Drain	Coarse screen, single shallow tray with Absorbent W	ED-As	118 gpm
Enviro-Drain	Fine screen, single deep tray	ED-Sd	32 gpm
Enviro-Drain	Coarse screen, single deep tray		141 gpm
Stormwater Services	Sock without absorbent	SS-2	exceeded 167 gpm

1. Maximum capacity of flow measuring flume.
2. The Stormwater Type 1 was not evaluated in this test because it is designed to remove sediments by settling in the trays rather than by filtration through the bottom of the trays.

Field-Conditioned Units
Treatment-capacity data collected during the second bench-test sequence are presented in Table 5. These tests, combined with field observations, indicated that the trays in the Enviro-Drain insert dropped below the maximum test rate of 24 gpm and that the insert was unable to treat even the nominal test flow of 6 gpm after the first field conditioning session. The Aqua-Net unit designated AN-AW exhibited similar reduction in the permeability of the treatment area to a level below the basic test rate (6 gpm), while the unit designated as AN-As maintained a treatment capacity which was close to the maximum test rate of 24 gpm, but still well below the target value of 60 gpm. The capacity of the Stormwater Services unit always exceeded 24 gpm; while the test facility could not test the unit up to the target rate of 60 gpm, the water level in the Stormwater Services units remained well below the overflow when tested at 24 gpm.

Table 5. Treatment Capacities of the Inserts After Field Use. The values presented below are from test on units which where neither configured nor evaluated in the same manner as those used in the "new-condition" tests. For this reason, these data are not directly comparable to the values presented in Table 4. Flow rates are in gallons per minute, rainfall is in inches.

Table 5a. Units Installed in Employee Parking Lot Area.

VENDOR	Insert	TEST 1 No field exposure	TEST 2 0.74" rainfall	TEST 3 1.30" rainfall	TEST 4 1.99" rainfall	TEST 5 4.55" rainfall
Aqua-Net	AN-Aa	exceeded 6	5	2	--	--
Stormwater Services	SS-2O	exceeded 6	exceeded 24	exceeded 24	exceeded 24	exceeded 24

Table 5b. Units Installed in Commercial Parking Lot Area.

VENDOR	CODE	TEST 1 No field exposure	TEST 2 0.83" rainfall	TEST 3 1.46" rainfall	TEST 4 2.21" rainfall	TEST 5 5.25" rainfall
Aqua-Net	AN-As	exceeded 6	24	21	20	
Enviro-Drain	ED-SAA	exceeded 6	4.6, 2.2	8.2, 9	1.4, 3	
Stormwater Services	SS-2O	exceeded 6	exceeded 24	exceeded 24	exceeded 24	exceeded 24

Note: For the Envio-Drain unit the first number indicates the flow through the upper tray and the second number indicates the flow through the lower tray.

3.2B Overflow-Capacity Test Results

The results in Table 6 show that the goal of 167 gpm, representing the capacity of the catch basin grate, was not achieved with two of the configurations: one Enviro-Drain unit (ED-As) and one Stormwater Services unit (SS-1). The capacities of these units were found to be 106 gpm and 143 gpm, respectively; considerably less than the target flow of 167 gpm. Note that one Enviro-

Drain unit reached the hydraulic goal and one did not. The difference in observed results is due to a difference in the overflow areas in the two units. The unit designated as ED-As has a smaller overflow area.

It is also important to consider that a flow of 167 gpm represents the approximate capacity of the grate when there is no standing water over the grate. When the flow depth increases, as would occur during an extreme storm, the capacity of the grate increases. It is not known from the tests performed in this study whether the grate, or the overflow area of the insert, ultimately limits the flow into the catch basin. If the latter, the insert may extend the period of street flooding during extreme storms.

Table 6. Hydraulic Capacity of High-Flow Outlet. Flow target: 167 gpm.

VENDOR	CONFIGURATION	CODE	MAXIMUM FLOW OBSERVED
Aqua-Net	Basket with Absorbent W	AN-A	exceeded 167 gpm
Enviro-Drain	Shallow single tray	ED-As	106 gpm
Enviro-Drain	Deep, two tray unit	ED-SAA	164 gpm
Stormwater Type I	Double box unit with fabric	SS-1	143 gpm
Stormwater Type II	Sock without absorbent	SS-2	exceeded 167 gpm

3.2C Field Observations of the Hydraulic Characteristics

Field observations indicate that with some configurations the stormwater can enter the catch basin without passing through the insert; instead the stormwater enters the catch basin between the pavement and the outer edge of the grate frame, and then passes beneath the frame of the insert. The short-circuiting was observed to a varying degree with all configurations except the fabric Stormwater Services units.

3.3 Conclusions Regarding Hydraulic Performance

- Catch basin inserts may not meet the Ecology criteria that a treatment BMP must be able to treat all storm flows up to the peak of the 6-month event. Based on this observation, inserts are not recommended as a substitute for other water quality BMPs unless the contributing area to each drain inlet is very small or it can be demonstrated that the specific insert does, in fact, meet the required treatment rate.
- Catch basin inserts are unlikely to contribute to local flooding since nearly all of the inserts tested were able to meet the target test rate for overflow capacity. Care should be taken, however, to avoid configurations which may cause flooding. The study did not address flooding caused by clogging of the overflow area.

CHAPTER 4 -MAINTENANCE

Chapters 2 and 3 presented results of experiments designed to determine the hydraulic and pollutant-removal characteristics of catch basin insert. In this chapter, the results of these studies, combined with the field observations made by the study team, will be used to address issues raised by maintenance personnel from the participating agencies after being introduced to catch basin technology. Issues, observations, and suggestions which were not addressed by the study, but that were raised by the maintenance personnel, are also presented.

4.1 INSTALLATION AND HANDLING

The study found, that with few exceptions, the units tested are relatively easy to maintain requiring only simple equipment.

Maintenance personnel attending the insert demonstration were concerned that the time and crew size required to clean inserts would be as great as for cleaning sumps. However, observations made during this study suggest that the time to clean inserts will likely be less than for sumps. The Port of Seattle compared the time to clean 18 inserts (Stormwater Service Type I) with the sumps located in the same catch basins. The sumps were 20 inches by 24 inches by 3 feet (below the outlet invert). It took one person 90 minutes to clean all 18 inserts. In contrast, it took two eductor truck operators about three hours to clean the sumps including time to discharge decant water twice into a sanitary sewer manhole at the site.

Most of the inserts evaluated in this study are light weight and can be removed and maintained by one person with relative ease. Cleaning does not require sophisticated equipment such as an eductor truck. The sediment can be placed in a garbage can placed in a pickup truck. Gloves should be worn; one insert had sharp edges that caused a serious injury to a member of the CBIC.

A two-person crew will be necessary in two situations: First, if the units are heavy (such as those that are made of stainless steel, contain heavy media such as activated carbon, or where units are intended to trap large amounts of sediment from stock piles or construction areas); and if the units are located in areas where traffic safety is an issue. Alternatively, a fork-lift, if available, may be used to safely remove the inserts. This technique is being used at least one commercial site in the Seattle area.

In the Port of Seattle study, decant was not a problem since the units used drained completely between events. During the "field-conditioning" periods in the CBIC study, most of the inserts contained standing water when removed for bench testing. In some cases the water remaining in the inserts (up to one or two gallons) was extremely oily. This problem might have been overcome had the inserts been allowed to drain for a few days prior to removal. If the units can not be left to "self decant," maintenance will have to include a means of properly disposing of the contaminated water. Contaminated water from the inserts must not be poured on the ground or into the storm drain, and can not be disposed as solid waste.

4.2 POLLUTANT REMOVAL (PERFORMANCE)

The study demonstrated that the units were not effective at removing fine particles, but that the inserts did remove course sediments and debris. While the inserts varied in their ability to remove oil and grease, most units would provide at least some level of treatment if maintained on a regular basis.

The maintenance personnel believed that the primary benefits of inserts are capturing oil and grease and capturing sediment at construction sites. They did not think much benefit would be gained if trying to capture sediment in street runoff because the sumps in catch basins already serve this function. This belief is generally supported by the study.

For a complete discussion of the pollutant removal characteristics of inserts, please see Chapter 3

4.3 MAINTENANCE FREQUENCY AND SCHEDULING

The study found that maintenance needs varied with the pollutant-removal objectives.

Maintenance personnel were concerned about both the frequency and scheduling requirements associated with insert use. In particular, they were concerned that, for wide-spread street use, the frequency and need to maintain inserts in a timely manner would make insert use impractical. Maintenance staff did feel that the inserts could be used at smaller commercial sites and at maintenance shops where dedicated maintenance workers would have more control over the timing and frequency of insert maintenance.

4.3A Maintenance Frequency with Regard to Sediment and Debris

The study demonstrates that units configured for the removal of course sediments and debris may go several months without maintenance.

Most of the units accumulated relatively little material over the three-month test period. This is apparent from the results presented in Table 5. The frequency of maintenance will depend on the time of year and site conditions; however, it is likely that for most sites the units configured for sediment and debris removal need not be cleaned more frequently than once every three months. Inserts used for sediment control in construction areas or around stock piles will need to be cleaned much more frequently. (Note: Inserts should never be used in place of source control practices since the finer sediments will not be captured.)

4.3B Maintenance Frequency with Regard to Petroleum Hydrocarbon

The study demonstrates that the units configured for oil and grease removal require frequent maintenance and that this frequency varies between the units tested.

The maintenance frequency for inserts configured for oil and grease removal is primarily dependent upon site conditions (oil and sediment loading) and the ability of the insert to keep the incoming stormwater in contact with the absorbant. Characteristics of the absorbant used in the study also affect insert performance.

In most cases, the maintenance cycle of the inserts tested was limited more by clogging of the filter surface or associated screens, than by actual (oil) saturation of the absorbant. Once the surfaces of the oil-absorbing media becomes inaccessible to the incoming stormwater, the filter media must be shaken or stirred-up to expose fresh media. Where sediment is a problem, maintenance will need to be very frequent (perhaps as often as after every rainfall event) but will not always include replacement of the media during each "maintenance event." Street or parking lot sweeping may reduce the maintenance frequency of inserts which have this problem.

Inserts which are able provide a degree of separation of the filter media and sediments are likely to last six weeks or more without maintenance. During the study, one unit was still providing approximately 50 percent oil removal after six weeks and approximately five inches of rain. At this point, the media appeared to be completely saturated, but was still trapping oil and grease, perhaps, through the continued build up of hydrocarbons on the surface of the media. Using a dead-storage area that allows sediment to settle out below the floating media appears to be instrumental in maintaining contact between the media and the incoming stormwater in this unit.

While the ability of the insert to maintain contact between the stormwater and the absorbant appears to be the key to achieving a relatively long maintenance cycle, the characteristics of the media may also affect maintenance needs. During the study, the wood fiber product used in some inserts appeared to contribute to the blinding of the screens used in the insert.

A second limitation of the wood fiber product used was that it can become saturated and decompose, limiting its field life to a month or two. Synthetic media do not appear to have this problem. Manufactures of the wood fiber media (which was developed originally as a spill clean-up tool) are currently working on variants of the product which may increase its usefulness in inserts.

4.5 Disposal of Sediment and Spent Media

Sediment and spent-media analyses conducted in this study indicate that the material will not be classified as dangerous waste and, in most cases, can be disposed of in municipal land fills.

Maintenance staff were concerned that trapped sediments and spent media would be difficult to dispose of. They also indicated an interest in being able to separate debris and sediment which could be disposed of as unregulated solid waste from spent media and sediment potentially requiring treatment as a hazardous or regulated waste. Maintenance staff indicated that a principle advantage of using inserts would be that there would be no liquid waste (decant) to dispose of.

The material accumulated in the inserts and media (if present) was characterized to determine appropriate methods of disposal. Since the amount of flow passed through the inserts during the bench tests was minimal in comparison to the stormwater experienced by the inserts at the field sites, the material tested was essentially what was captured at each field site. The following regulations were used as the basis for determining disposal options: WAC 173-303, Dangerous Waste Regulations; WAC 173-340, Model Toxics Control Act; and the landfill restrictions of regional jurisdictions.

The results of the waste characterization are shown in Table 7. Eleven of the twelve samples analyzed (two samples were from one insert) met standards that are likely to allow disposal at a conforming sanitary landfill. (Standards vary from jurisdiction to jurisdiction.) The sample that exceed the criteria cited above contained had a TPH value of 170,000 mg/kg, which exceeds landfill standards of 30,000 mg/kg. This unit was located in a Park-and-Ride and may have been subjected to illegal dumping of used motor oil.

The above results are consistent with various analyses of sediments removed from catch basin sumps; most of the captured material can be classified as solid waste. Therefore, the disposal of captured materials from inserts should not be any more difficult than the disposal of sediments from catch basin sumps; however, one vendor has reported spent media which could not be disposed of as solid waste because contaminant concentrations exceeded solid waste standards.

The presence of pollutants in the filter media will increase in proportion to its success in removing pollutants from the stormwater. It is possible that disposal problems will arise as insert structure and media are improved. The nature of the media itself will also effect disposal options; wood fiber products can be composted or incinerated, while petroleum-based products will probably have to be disposed of in a municipal land fill.

Table 7. Analysis of Captured Material. Values presented are the mean concentrations and ranges for the samples collected from the 12 inserts used in the first sequence of the pollutant-removal study described in Chapter 3.

ANALYTE	RANGE OF CONCENTRATIONS	MEAN OF CONCENTRATIONS
TPH	290 to 170,000[1] mg/kg	7,900 mg/kg
Arsenic	ND[2]	ND
Cadmium	ND to 1.3	0.60
Chromium	7.2 to 82	22
Copper	17 to 730	62
Lead	27 to 310	78
Nickel	6.1 to 21	16
Zinc	70 to 3,200	270
Acenaphthene	ND	ND
Acenaphthylene	ND	ND
Anthracene	ND	ND
Benzoanthracene	ND	ND
Benzopyrene	ND	ND
Benzofluoranthene	ND	ND
Benzoperylene	ND	ND
	ND	ND
	one hit at 0.58	ND
	ND	ND
	four hits at 1.0,1.3,1.4,2.1	ND
Fluorene	ND	ND
Indeno(1,2,3-cd) pryrene	ND	ND
Naphthalene	ND	ND
Phenanthrene	one hit at 1.3	ND
Pyrene	two hits at 1.2,1.6	ND

1. The highest TPH concentration was in the media from the Aqua-Net unit designated AN-A which was installed in the Park-and-Ride site during the first test sequence.
2. Not Detected.

4.6 OTHER OBSERVATIONS BY MAINTENANCE PERSONNEL

Following are observations not discussed in the above sections, but which were brought to the attention of the study team by maintenance staff attending the insert demonstration.

4.6A Favorable Aspects of Insert Use

- Don't have to use an eductor truck.
- Inserts remove oil whereas standard catch basins do not.

4.6B Unfavorable Aspects of Insert Use

- Units will not fit all catch basins; there are subtle variations between catch basins.
- Potential for back injuries when cleaning the inserts.

4.6C Other Ideas and Questions Concerning Insert Use

- Which units are more likely to clog?
- How difficult will it be to remove the grate to clear the unit if the grate area is flooded because debris has clogged the overflow area of the insert?
- Suggested giving out inserts free to businesses, similar to giving away compost bins.
- Need to recommend specific units for specific situations.
- Suggested placing inserts at the end of the drainage system rather than individual units in each catch basin.
- Businesses that provide drainage system cleaning services to private landowners can augment their services to clean inserts. However, these businesses must continue to provide eductor service since the sites with inserts will continue to need sump cleaning (although presumably less frequently).
- Most appropriate in parking lots, maintenance yards, small businesses, and at construction sites.

CHAPTER 5 - INSERT SELECTION AND USE

5.1 RECOMMENDATIONS ON APPROPRIATE USES OF INSERTS

Following are the CBIC's specific recommendations concerning the use of catch basin inserts for the removal of pollutants from urban runoff. The opinions presented are based on the study team's observation during the course of the project and do not necessarily represent the regulatory position of the agencies involved in the study. The suitability of inserts for a specific use will also vary with site conditions and climate. For information on the accepted uses of catch basin insert, contact your local public works department or stormwater utility.

5.1A If the objective is to remove fine particulate pollutants

Recommendation: The CBIC *does not recommend* the use of inserts if the user's objective is to remove fine particulate pollutants. Furthermore, inserts are *not recommended* as a substitute for wet ponds, constructed wetlands, grass swales, sand filters or other related BMPs where the primary objective is to remove particulate or dissolved pollutants such as metals and phosphorus.

Reasoning: The bench tests performed in this study did not demonstrate an appreciable reduction in the TSS concentrations of water containing fine sediment. In addition, the results of the Port of Seattle study on one of the inserts suggests that the inserts do not provide an incremental increase in performance over the drain inlets/sumps without inserts.

Studies of currently accepted BMPs, such as well designed and maintained wetponds and grass swales, have demonstrated that they are capable of removing particulate pollutants when used to treat stormwater such as was used in this study. It therefore must be concluded that inserts cannot be substituted for the currently accepted BMPs without further research and development.

6.1B If the objective is to remove coarse sediment

Recommendation: The CBIC *recommends* that inserts be used in unpaved areas where the sediment concentration in the stormwater is expected to be high and will include a substantial percentage of course material. Potential sites for this application include construction sites, unpaved roads and unpaved industrial sites. Inserts should be considered equivalent to currently accepted inlet protection BMPs described in the Ecology manual (Ecology, 1992).

Reasoning: The CBIC did not set out to test inserts as an inlet protection BMP for construction sites; however, the study observed that inserts are able to capture and retain coarse sediment. While inserts may not be any more effective than sumps at capturing sediment, they will likely provide an advantage over the currently recommended BMP for inlet protection in the Ecology manual which is to place filter fabric across the top of the catch basin with straw bales or a gravel filter around the inlet. These BMPs often becomes plugged, resulting in ponding around the catch basin. Ponding makes it difficult to replace the BMP and to clean out the inlet sump. Typically, the accumulated material washes down the catch basin as the construction worker makes the necessary repairs.

In comparison, a catch basin insert bypasses all flows after it is full and is not likely to result in ponding. This means that maintenance staff will not have to work in a pond of water to clean the insert. Also, an insert is easier and cheaper to clean than a sump; the latter may require a vactor truck.

5.1C If the objective is to remove petroleum hydrocarbons

Recommendation: The CBIC does *not recommend* the use of inserts in new developments in lieu of oil/water separators, but considers them *acceptable* when used as an oil-control BMP at existing sites.

Inserts should be used for oil control only if the following two conditions are met. First, the vendor demonstrates that the proposed absorbant can remove petroleum products. Second, the insert user must be able to maintain the system at the required frequency. Potential sites for this application include maintenance shop yards, apartment complexes and small retail parking lots.

Reasoning: The recommendations are not based on unequivocal data that compare inserts to oil/water separators. Rather the recommendation is based on the premise there is insufficient data at this time to allow a major change in current policy. There are advantages of oil/water separators over inserts, particularly in developments that may be susceptible to higher than normal oil concentrations. The first advantage of separators is maintenance frequency. Separators may have to be cleaned as little as once or twice a year. In contrast, the absorbant in catch basin inserts will have to be serviced or changed, at a minimum, every four to six weeks, and in some instances, as often as after every storm event. The second major advantage of separators is that they provide a measure of protection from large spills while the catch basin inserts studies are unlikely to retain more than about a quart of oil.

The CBIC has observed that most inserts can, with appropriate maintenance, approach the 10 mg/l effluent target generally associated with oil/water separators. Inserts may be a valuable pollution-control tool where installation of an oil water separator is either physically impractical, or is not specifically required.

It has been suggested that inserts be used in conjunction with a down-turned elbow as a means of holding an absorptive material in the sump, rather than as a filter suspended above the water surface. While this strategy was not studied by the CBIC, the idea is worth pursuing.

5.1D If the objective is to remove dissolved pollutants

Recommendation: The CBIC does *not recommend* inserts where the objective is to remove dissolved pollutants if the inserts use the removal mechanisms present in the inserts tested by the CBIC.

Reasoning: One of the Enviro-Drain units tested in this study contained activated carbon which theoretically has the capability of removing dissolved pollutants. This study did not, however, find the activated carbon to be effective. It is possible that units capable of removing dissolved pollutants will be commercially available in the future. Efforts are currently under way to develop media which are effective at removing dissolved pollutants.

5.1E If the objective is to remove trash and debris

Recommendation: The CBIC *recommends* that inserts be used where the removal of trash and debris is the objective.

Reasoning: The CBIC did not set out to examine this question; however, visual observation of the inserts tested indicate they are effective at removing trash and debris. Debris removal improves the aesthetics of receiving waters and possibly the pollutant loading as well. However, floatables can serve as growth surfaces for bacteria and can release toxic pollutants these materials deteriorate. Inserts with simple mesh screens are sufficient for the removal of debris. Testing is needed in areas of heavy leaf-fall to ascertain the susceptibility of overflow areas to be plugged by leaves. Inserts installed for this purpose should include a means of preventing the loss of previously-captured material during high flow events.

5.1F If a catch basin lacks an adequate sump or oil trap

Recommendation: The CIBC *recommends* that inserts be used when an existing catch basin lacks a sump or has an undersized sump, and there is no treatment BMP such as a wet vault, wet pond or oil water separator located downstream.

Reasoning: While results from this study suggest that an insert does not significantly improve the performance of the catch basin, it does show that the insert can be used to capture at least some sediment and oil. Hence, where a catch basin lacks a sump or has an undersized sump, an insert should improve overall sediment removal performance of the catch basin. Furthermore, an insert configured for oil and grease removal and installed in a catch basin which is not fitted with a down-turned elbow, will certainly capture more oil than a catch basin without an insert. The degree of protection offered under these two conditions will be directly related to the attention given to the maintenance of the insert.

Note: Research by Lager (1977) suggests that an appropriately-sized sump is one in which the depth and width of the sump is at least four times the diameter of the outlet pipe. Hydraulic tests in the referenced publication found that the 4:1 configuration is needed for the sump to readily remove suspended solids in the stormwater.

5.1G If the objective is to reduce maintenance costs

Recommendation: The CBIC *recommends* that inserts be considered as a means of reducing maintenance costs of downstream BMPs.

Reasoning: Opportunities may exist where, while an insert may not increase overall performance, it may reduce the cost of maintaining a BMP already present at the site. Two examples are offered here:

- Placing an insert in catch basins leading to an oil/water separator may reduce maintenance costs for the owner. The owner's staff can easily replace the absorbant in the inserts, whereas the owner must hire a service company to clean the separator. If the absorbant is removed at the recommended intervals the owner should be able to dispose of the material through normal solid waste disposal. Check with the local jurisdiction.

- Small businesses may have very few catch basins in their parking lot. Hiring a service company to clean only a few sumps will incur a high unit-cost. The owner can easily clean an insert, thereby reducing the frequency of having to clean the sump and lowering the overall maintenance costs.

5.2 MATCHING SITE CHARACTERISTICS TO INSERT CAPABILITIES

It is recommended that the prospective insert user evaluate the field site, matching the characteristics of the site to the capabilities of the inserts under consideration. The following is offered regarding site characterization:

5.2A Evaluate Site Hydraulic Conditions

The buyer should determine the following about the site:
- Determine the catchment area draining to the catch basin to receive the insert.
- Using the Rational Method estimate the peak flow of the 6-month storm (use a rainfall depth of 0.65 of the 2-year event from your IDF curve or refer to Table 8).
- Calculate the capacity of the grate, using the equation presented in Appendix A.
- Calculate the capacity of the outlet pipe from the catch basin using Mannings Equation.

With the above information ask for the following information from the manufacturer:
- The flow capacity of the treatment area of the insert; that is, the rate at which stormwater passes through the insert without the use of the overflow or bypass area. This flow rate should be equal to or greater than the peak of 6-month storm calculated above.
- The hydraulic capacity (gpm) of the overflow or bypass area when the treatment area is clogged. This flow rate should equal or exceed the peak flow you calculated for either the grate or the outlet pipe, whichever is greater.
- Whether the overflow or bypass area is subject to blinding by large material such as leaves.

Table 8. Flow Estimates for 1/4 acre Drainages. Estimated peak flows using the Rational Formula assuming a 5-minute time of concentration, 2-year intensity estimate from WSDOT Hydraoulics Manual IDF Charts, and a C value of 0.9.

Location	Estimated 2-year peak I (inches/hour)	Estimated 6-min. peak I (inches/hour)	Peak Q C*I*A (c.f.s)	Peak Q C*I*A (gpm)
Aberdeen/Hoquiam	1.8	1.206	.251	113
Shelton/Neah Bay/Ashford	1.7	1.139	.237	107
Quinault	2.5	1.675	.348	157
Forks	2.3	1.541	.321	144
Humptulips	1.8	1.206	.251	113
Bremerton/Sumner	1.9	1.273	.265	119
Olympia	1.7	1.139	.237	107
Port Angeles	1.3	0.871	.181	82
Olympia	1.7	1.139	.237	107
Port Townsend	1.3	.871	.181	82
Seattle	1.4	.938	.195	88
Sequim	1.4	.938	.195	88
Tacoma	1.9	1.273	.265	119
Tatoosh Island	2.2	1.474	.307	138
Vancouver	2.1	1.407	.293	132
Anacortes/Centralia	1.4	.938	.195	88
Bellingham	1.7	1.139	.237	107
Everson/Longview	1.8	1.206	.251	113
Arlington/Morton/Woodland	1.8	1.206	.251	113
Shuksan/Cathlamet	1.9	1.273	.265	119
Raymond	2	1.34	.279	126
Skykomish	2.1	1.407	.293	132
Darrington	2.3	1.541	.321	144
Long Beach	2	1.34	.279	126
Ellensburg/Pasco	1.4	.938	.195	88
Othello/Vantage	1.5	1.005	.209	94
Moses Lake/Washtucna	1.8	1.206	.251	113
Goldendale/Ritzville	1.8	1.206	.251	113
Coulee City	1.9	1.273	.265	119
Brewster/White Salmon	1.9	1.273	.265	119
Cle Elum/Pullman	1.9	1.273	.265	119
Republic/Leavenworth	2.1	1.407	.293	132
Stevens Pass/White Pass	2.5	1.675	.348	157
Stevenson	2.7	1.809	.376	170
Snoqualmie Pass	3.8	2.546	.530	239
Spokane	2	1.34	.279	126
Walla Walla	1.7	1.139	.237	107
Yakima	1.4	.938	.195	88
Almira	1.5	1.005	.209	94

5.2B Evaluate Site Pollutant Loading Conditions

The buyer should consider the following:

- Determine if there are conditions or activities that might contribute pollutants or sediment to the catch basin. Will the loading be light or particularly heavy?
- Determine the pollutants of concern present in the stormwater - is your concern sediments, petroleum products, metals, nutrients, particulate pollutants, and/or dissolved pollutants?

Having gathered the above information, ask the vendor for the following information:

- Description of the insert media. Are its capabilities appropriate for the target pollutants?
- Weight of the unit when new and when at the end of recommended maintenance cycle;
- Life of media, susceptibility to deterioration; and,
- Operation and maintenance considerations and recommendations.

5.3 INSERT DESIGN FEATURES

Experience gained by the CBIC during this study leads to several observations on insert design. It is recommended that prospective buyers of inserts consider the following design features before purchasing specific models. The manufacturers of inserts should address these issues in the development of new models.

5.3A Screens and Filter Fabric

Mesh screens are prone to clogging. In this study, a 32-mesh screen, and an insert using filter fabric, clogged after only a few minutes when fine sediment from a typical parking lot was washed into the inserts during the treatment capacity tests. Coarse (eight- or twelve-mesh) screens may be more appropriate for debris removal.

5.3B Protection of Oil-Absorbing Materials from Excess Sediment

In several instances, contact between the stormwater and the oil-absorptive media was reduced or eliminated long before the absorptive capacity of the media had been reached. This was usually due to the accumulation of sediment on the media. A system which allows sediment to settle out before the stormwater passes across the media would more effectively use the media, and require less-frequent maintenance.

5.3C Energy Dissipation and the Treatment Area

Without dissipation of the energy in the incoming stormwater it is likely previously captured sediments will be re-suspended. An energy dissipation device is needed.

5.3D Bypass

Inserts should have the capability of passing the maximum expected flow for the proposed field site and should not limit the capacity of the sump outlet. A bypass area designed to prevent the re-suspension of sediments accumulated in the treatment area is preferred.

5.3E Grate Seal

Short-circuiting of water past the insert via the outside edge of the grate frame must be avoided. During field visits the study team noticed that in most test catch basins some of the stormwater (essentially, all of the stormwater during modest rainfall events) entered the catch basin between the grate and the catch basin frame rather than through the grate and insert. This occurred with all models except the fabric Stormwater Services inserts. The fabric used in these units created an effective seal between the catch basin frame and grate. In contrast, the more rigid models tended to elevate the grate slightly, increasing the potential for low-flow bypass.

5.3F Accommodating Catch Basin Grate Configurations

The grate must seal flat against the pavement. One unit tested in this study had a separate flow-diversion flange. The reinforcing rib of the grate rested on this flange, thus raising the grate one half inch, making the grate unstable. This situation is unacceptable and could lead to problems such as a hazard to bicyclists, pooling around the grate, dislodging of the grate by passing cars, and possible deformation of the insert by the weight of vehicles. Placing the internal flow diversion flange lower in the insert will avoid this problem.

At this time standard units do not always accommodate the range of existing grates and frames. Variations in rib thicknesses and alignment tabs, and the presence of locking tabs, will affect the fit of the insert in the drain inlet. Vendors are aware of these variations and are generally willing to work with clients to avoid these problems.

5.3G Flow Path Through the Insert

Since the ability of the filter media to absorb oil is dependent upon the stormwater coming in contact with the oil-absorbent, inserts should be designed so that the time and extent of contact are maximized.

5.3H Ability to Lock Insert into the Catch Basin

While the inserts installed in the field for this study were neither vandalized nor stolen, it may be desirable to have a means of locking the inserts in place; however, during autumn in locations where there is heavy leaf fall, the use of a locking mechanism may interfere with emergency removal of the inserts.

5.3I Complete Application and Maintenance Instructions

Adequate information concerning how and when to maintain the units was generally not furnished with the products tested; however, the vendors involved in this study do work closely with their clients. If inserts are used more widely, vendors will need to provide explicit instructions on the appropriate use and limitations of the products. A means of assuring the transfer of maintenance information when commercial facilities change ownership is also needed.

5.4 VALIDATION TESTING

The CBIC recommends the following testing protocol to demonstrate the capability of different inserts models:

The manufacturer is at liberty to do all of the testing in the field if it can assure the following:

1. The manufacturer is able to effectively measure influent and effluent concentrations using composite, flow-weighted sampling.
2. The concentration of the pollutant or pollutants of interest in the influent is at least 5 times the detection limit. This requirement is necessary to assure that the performance observed is real and does not reflect the uncertainty of laboratory analysis.

3. The area draining to the field unit should be about 0.25 acre.

Alternatively, the manufacturer can follow the procedure used in this study—bench testing of units that have been seasoned in the field. The bench-test must be performed with stormwater that is representative of urban runoff. The test water should be altered if necessary to raise the influent concentration of the target pollutant to at least 5 times the detection limit of the pollutant. The artificial alteration of the test water will probably be necessary when testing for the removal of dissolved pollutants and total petroleum hydrocarbons. It will not usually be necessary when performance testing for sediment and particulate pollutant removal.

The unit should be tested when "fresh" (before placement in field), and successively through several inches of rainfall. The recommended accumulated rainfall depths vary with the pollutant of interest as follows:

Pollutant of interest	Incremental rainfall depth prior to each test	Aggregate rainfall depth prior to last test
petroleum hydrocarbons	1/2"	4"
sediments	2"	8"
dissolved pollutants	1/2"	4"

When testing for sediment removal, provide an evaluation of the size distribution of the sediment removed.

The manufacturer should provide a certified statement that the test results it presents includes all, not selected, data. The sample analysis must be done by a state-certified laboratory. The original data sheets as provided by the laboratory should be included in the vendor's performance report. The manufacturer should include the detection limits for the pollutant of interest. The manufacturer should provide evidence that re-suspension of captured sediments does not occur.

Alternative testing criteria, based entirely on the hydraulic characteristics of both new and used inserts, is included in the King County Surface Water Design Manual excerpt in Appendix E.

CHAPTER 6 - FURTHER EVALUATION

Prior to the formation of the CBIC, local jurisdictions were receiving mixed messages about the potential value of catch basin inserts as an urban runoff BMP. By conducting the current study, the CBIC found that the inserts were capable of removing hydrocarbons, debris, and coarse sediment from urban runoff. The inserts did not effectively remove fine sediment and associated pollutants, and did not appear to remove dissolved pollutants.

The required maintenance intervals ranged from after nearly every event for some inserts configured for oil removal, to an estimated six months to a year for units installed simply to remove coarse sediment and debris. Pollutant removal performance and field life between maintenance cycles were most often limited by clogging of the filter surfaces and subsequent bypass of the treatment areas. Even with the treatment areas completely blinded, the units were unlikely to contribute to local flooding so long as the high flow relief areas were not plugged.

Maintenance of the inserts was generally simple, requiring a crew of one or two workers and a pick up truck.. In most cases spent media could be disposed of as unregulated solid waste. Use of catchbasin inserts could reduce the need for educator truck services, and may prolong the maintenance period for other treatment BMPs. The study concluded that catch basin inserts should not be used in place of more conventional treatment BMPs, but that they could be used in conjunction with house-keeping BMPs as part of a comprehensive pollution-prevention program.

The current study provides an introduction to catch basin insert technology. Several study questions which either came up during the course of the study, or which were beyond the study scope from the beginning, are listed below.

- How well do inserts remove coarse sediments from construction sites?
- How susceptible are the high flow outlets to clogging by leaves and large debris? Which clogs first, the inlet grate or the insert?
- How do inserts perform in areas with frequent or extended winter freezes?
- Are there media which can be used to remove dissolved pollutants under the relatively harsh conditions found in a drain inlet?
- Can inserts be used to treat certain types of process waste water prior to discharge to storm drains or sanitary sewers?

At the time of this writing, the following local agencies were conducting evaluations related to catch basin inserts. Others considering related research are encourage to contact these agencies or the CBIC to avoid duplication of effort and foster data sharing.

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Removal of Course Sediments

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Testing of Media for Dissolved Metals Removal

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